SELECTION OF A NAVAL BASE SYSTEM FOR PATROL VESSELS: A COST-EFFECTIVENESS ANALYSIS

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Indonesian naval patrol vessels which are operated in the waters of the Riau Islands (East of Sumatra) must return to their home base at Surabaya for their periodical maintenance and repair. Establishment of a naval base in that area that can provide maintenance and repairs to the patrol vessels could save the time and cost lost in steaming the distance to Surabaya and return.

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ABSTRACT

Indonesian naval patrol vessels which are operated in the waters of the Riau Islands (East of Sumatra) must return to their home base at Surabaya for their periodical maintenance and repair. Establishment of a naval base in that area that can provide maintenance and repairs to the patrol vessels could save the time and cost lost in steaming the distance to Surabaya and return.

Three prospective sites were considered for potential development as a naval base. From these three sites six alternative base systems were developed. A cost-effectiveness methodology was used for selecting the preferred alternative.

The result of the analysis indicated that upgrading the existing facilities at Tanjungpinang to a naval station without maintenance and repair facilities and performing the maintenance and repair of the naval patrol vessels at Surabaya is the most cost-effective base system among the alternatives considered.

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I. INTRODUCTION

A. COST EFFECTIVENESS ANALYSIS

Compared with its wants, the resources at a nation's disposal are always limited. The allocating of scarce resources among competing objectives is of primary concern in most planning problems. The fact that objectives are always more numerous than the resources available to achieve them leads to attempts to find ways of more efficient utilization of the limited resources. As a result, some aids to decision-making, such as cost-effectiveness analyses, have been introduced in the U.S. Government, especially the U.S. Department of Defense [7].

"Cost-effectiveness analysis" can be defined as:

> An analytical technique for evaluating the broad management and economic implications of alternative choices of action with the objective of assisting in the identification of the preferred choice.
>
> 'Analytical technique' means a procedure or procedures utilizing a logical sequence of repeatable and verifiable steps that separate and examine the parts and interrelations of the performance and costs of systems, subsystems, components, and processes.
>
> 'Evaluating' means to ascertain the value or measure in quantifiable terms.
>
> 'Broad management and economic implications' means those grounds for inference that might be drawn from the effect upon the financial budget, profit return, market position, organizational structure, manpower, schedules, overall performance vis-a-vis the enemy, competitor or environment, and limited resources of one kind or another.

'Alternative courses of action' means those proposed plans (e.g., competitive military missions, alternative equipment configurations, facility designs, maintenance policies, labor utilization schedules, production schedules, and operating rates) that offer the decision-maker (often the customer of the cost-effectiveness study) an opportunity to select one that satisfies some criterion. [9]

In cost-effectiveness analysis, the first and most important step is to formulate and to research the problem. This means the analyst must clarify the issues, limit the extent of inquiry, search out the necessary data and relationships, and identify the various elements.

The essential elements in cost-effectiveness analysis according to Quade [7, 18, 19] are:

1. The objective or objectives. One of the first and important steps necessary to perform a meaningful evaluation of the alternatives is to establish the objective or objectives that is or are to be accomplished. Without such an identification of objectives, there is no framework for structuring the subsequent evaluations.

2. The alternatives. Once the objective has been established, the next step is to develop feasible methods that can meet the objective. To conduct a meaningful evaluation, at least two alternatives must be formulated. If only one alternative can be conceived, there is no use for further implementation of a cost-effectiveness analysis for purposes of system selection.

3. <u>The costs and benefits</u>. Cost represents the value of the alternatives that must be sacrificed [10]. The choice of a particular alternative method for accomplishing the objective involves the incurring of certain costs or the using up of certain resources. This implies that these resources are no longer available to be used for other purposes.

Effectiveness is the desirable effect or benefit gained by incurring costs. Effectiveness is represented by some measure of performance or level of output of the alternative or system being studied in a cost-effectiveness analysis.

4. <u>A model or models</u>. A model is an abstract representation of the real situation under study. It may take any numerous forms, from a set of mathematical equations or a computer program to simple sets of relationships that are sketched out in the mind and not formally put down on paper. In cost-effectiveness analysis, models are required to predict the costs that each alternative will incur and the extent to which each alternative will attain the objective.

5. <u>The criterion</u>. A criterion is a rule or standard for ranking the alternatives in order of desirability by which one alternative can be chosen in preference to another. It provides a means for weighing cost against effectiveness.

For problems of choice among possible systems or competing alternatives there are two principal conceptual approaches:

a. Fixed effectiveness approach. For a specified level of effectiveness to be attained in the accomplishment of some given objective, an attempt is made to seek that alternative which is likely to achieve that specified level of effectiveness at the lowest cost.

b. Fixed budget approach. For a specified cost level to be used in the attainment of some given objective, an attempt is made to identify that alternative which is likely to produce the highest effectiveness.

Essentially, these approaches are equivalent. Minimizing the cost of attaining a certain level of effectiveness inevitably implies that that level of effectiveness is maximized for that given level of cost. Either or both approaches may be used, depending upon the context of the problem at hand.

Since the objective is that comparison among alternatives can be made, either the effectiveness or the cost (budget) has to be specified.

A common criterion error which causes confusion is the attempt to maximize benefit or effectiveness while simultaneously minimizing cost. The maximum effectiveness may be infinitely large, and the minimum cost is zero. Thus, an attempt to find such alternative is doomed to failure at the outset, because such an alternative does not exist.

B. SCOPE OF THE STUDY

A system of support activities is required to provide logistic support and combat readiness to Indonesian naval vessels. Support activities in this context include naval shore facilities such as a naval station and a naval base, each of which is a command separate from the operating forces.

Decision-makers are sometimes faced with problems of choice, such as which of the existing facilities is to be assigned the task of providing support to the operating forces, and whether the existing facilities are to be developed or discontinued.

The purpose of this thesis is:

1. To select the most desirable site among the existing shore facilities, for purposes of providing logistic and other support to Indonesian patrol vessels.

2. To decide whether the support establishment is to be developed as a naval station or to be extended as a naval base. Cost and effectiveness measures are to be used as the selection criterion.

In Chapter II the problem and the objective to be achieved are formulated.

Chapter III discusses the alternative means to accomplish the specified mission.

In order to provide some background material, a discussion of the concept of costing is presented in Chapter IV. This chapter also includes a cost model for estimating the total cost of each alternative system.

The selection of an appropriate measure of effectiveness for the proposed alternatives and the method of measurement of this effectiveness are described in Chapter V.

Chapter VI deals with the comparison of the alternatives by plotting the total cost of each system against its effectiveness.

Finally, the last chapter provides some concluding remarks.

II. THE SCENARIO

The waters between Indonesia, Malaysia and Singapore are economically important to each of these countries. They form a waterway which connects places within each country and they also serve as a medium for transportation of trade between Indonesia and Malaysia and Singapore.

Recent increase of trade between Indonesia and the other two countries was followed by an increase of illegal trade -- the smuggling of goods through the waters south of Malaya and Singapore [11]. This illegal activity is detrimental to Indonesia in many ways. It especially harms the Indonesian economy which the current government is trying hard to build in two ways:

1. This flow of smuggled goods to and from Indonesia has discouraged legitimate business, especially small local business, by unlawful competition. Sooner or later, the small legitimate local business will be forced to stop their operations due to the illegal competition.

2. The Indonesian government was deprived by the loss of millions of dollars of its annual revenue from import taxes or custom duties.

It is known that the means being used by the smugglers to transport the goods are small motorized boats operating among the many islands south of Singapore [11]. To prevent more damage to the Indonesian economy, and also to retain good trade relationships with Malaysia and Singapore, immediate action must be taken to stop this smuggling activity.

It is the mission of the Indonesian Navy to safeguard the Indonesian waters from any intruder and prevent the use of the Indonesian waters for any illegal activity. It is, therefore, the task of the Indonesian Navy to tighten its control on the waters between Indonesia, Malaysia and Singapore. It must increase or intensify the naval patrolling in this area in order to apprehend these smuggling craft or at least to prevent their crossing Indonesian waters.

At present, naval vessels that are operated in the waters between Sumatra, Malaya and Singapore must return to their home base at Surabaya for their maintenance and repairs. This base lies about 800 nautical miles from the smuggling area. Maintenance and repair work are done at the home base due to lack of maintenance and repair facilities near the operating area. The operating area or patrolling area of the naval vessels is the waters between Sumatra, south Malaya and Singapore where the smuggling craft are suspected to cross.

In attempt to eliminate the transit from the operating area to the home base in order that more patrol time is available for the patrol vessels some alternatives in addition to the present patrol vessel base system are being considered. If adopted, the alternative base system will permit more intensive patrolling of the operating area.

A cost-effectiveness analysis is being conducted in this thesis to find out which of the alternatives is the most cost-effective in accomplishing the proposed mission.

III. THE ALTERNATIVES

Each alternative system to accomplish the mission will consist of the naval patrol vessels and the supporting establishment. Their characteristics will be described.

A. THE PROPOSED VESSEL

In order to carry out the assigned mission, it is proposed that small two-engined patrol vessels which have reasonable speed (similar to the KRI SIBARAU class battleship) are sufficient to counter the small motorized boats used by the smugglers to transport the contraband goods. This suggested type of patrol vessel is to be manned by 19 military personnel consisting of 3 junior officers, 5 petty officers, and 11 seamen. Its other features are as follows: maximum speed = 23 knots, economic speed (two engines) = 16 knots, range at economic speed = 750 nautical miles, range at 11 knots (one engine) = 1750 nautical miles, average fuel consumption = 100 gallons/hour, average lubricant consumption = 7 pints/hour [13].

B. THE SUPPORTING ESTABLISHMENT

As mentioned previously, all patrolling vessels which are deployed at the operating area must return to their home base which lies about 800 miles away from their operating area for

their maintenance, repairs and other logistic support. A considerable amount of time and cost is, therefore, wasted for cruising the distance from the operating area to the home base and return.

The establishment of a naval station or a naval base in the operating area that can provide maintenance, repair and other logistic support to the patrol vessels would save the time lost mentioned above. In addition, by stationing the patrol vessels only within their operating area, they will be available at any time when they are needed. They can also reach any reported position of a smuggler within a minimum amount of time. A more effective and efficient employment of these vessels may therefore be expected.

A naval base and a naval station both are naval shore activities in a given area or locality which are to provide logistic or other support to the operating forces. The difference between a naval base and a naval station lies in the size of the activities or the level of support they are capable to furnish to the operating forces.

Further description about a naval base and a naval station is provided in Appendix A.

C. THE ALTERNATIVES BEING CONSIDERED

Three prospective sites, which are in the operating area, are being considered for potential development as forward stations or bases for the patrol vessels. Some facilities have been built at each of these three sites. The existing facilities, however, do not fully meet the requirements of a naval base or of a naval station which is to provide logistic and other support to a force of 10 patrol vessels. Additional facilities and equipment are necessary to replace the old structures and equipment and to increase the support capability of the shore establishment in order that they can perform their functions as required.

Figure 1 on the next page is a map depicting the proposed sites.

The first site, Tanjungpinang (S-1), lies about 710 miles away from the home base (Surabaya). Its existing facilities are considered sufficient for its functioning as a naval station. Only some upgrading and replacement of old equipment are necessary to make this site acceptable as a naval station. For its functioning as a naval base, however, some housing will have to be built, and maintenance and repair facilities and ordnance facilities must be made available. Other facilities, such as medical and dental facilities, berthing facilities, and communication facilities will have

Figure 1
Map of the Sites Under Consideration

to be improved. An unfavorable aspect of S-1 is that is has a low depth of water near its piers; only small vessels can make use of its berthing facilities.

The second candidate, Tanjunguban (S-2), is situated about 30 nautical miles north of S-1. Compared to the first site, S-2 has fewer already-built facilities, but it has a better harbor site and better fueling facilities.

The third site, Dumai (S-3), has the fewest facilities of all the three sites. It lies about 900 nautical miles away from the home base.

From these three sites, the following alternatives are being considered for the naval base system for the patrol vessels that are being operated to perform the assigned mission:

Alternative 1. Establish a naval base at S-1 which can provide logistic and other support to the patrol vessels and which can also provide maintenance and repairs.

Alternative 2. Upgrade the existing facilities at S-1 to a naval station without repair facilities. Annual maintenance and repairs for the patrol vessels are to be carried out at the base in Surabaya.

Alternative 3. Establish a naval base at S-2 with repair and maintenance facilities that will have to be constructed.

Alternative 4. Upgrade S-2 to a naval station without repair facilities. For their maintenance and repairs the patrol vessels will have to sail to the home base.

Alternative 5. Establish a naval base at S-3 that can provide maintenance and repairs to the patrol vessels.

Alternative 6. Upgrade S-3 to a naval station without repair facilities. Maintenance and repairs for the patrol vessels will be done at the home base.

IV. THE COST OF ALTERNATIVES

A. UNITS OF COST

Each particular system alternative for attaining the objective will require the expenditure of a different set of resources. These resources, in the form of manpower, materials, facilities, and capital equipment, will have to be determined and made available before the system can be procured, operated and maintained over its life.

To be able to choose wisely which of the several different alternatives should be selected, the cost or the resources requirement of each alternative must be known and can be compared with the cost of other alternative systems.

However, since each alternative system will require the expenditure of different sets of resources, it would be difficult to compare the set of resources required for one system against a different set of resources for the other systems. For example, how could manpower be compared against machines or facilities against equipment? The difficulty comes in properly identifying and finding appropriate unit or common denominators for adding together the many dissimilar resource elements.

One way to overcome this difficulty is to translate the amount of the resource required into its monetary equivalent to obtain the resource over the total time it is needed. Measuring resources in monetary units has the following advantages:

1. It provides a common denominator for representing the worth of resources and for adding the different resource elements.

2. Budgets also use monetary unit as a measure [20].

Although for most purposes monetary costs serve as a sufficient measure of the resources needed to develop, procure, operate, and maintain a particular system, it should be noted that whatever measure of cost is chosen, it is really an index used to compare and rank alternatives. No single measure of cost is likely to be fully descriptive in presenting all pertinent resource information [8].

B. COST CATEGORIES

A decision to undertake a particular course of action should take into account its total cost impact over a projected future time period. It is, therefore, necessary to identify resource requirements in terms of the major life cycle phases of the new system under consideration. Generally system costs are identified and categorized as research and development

costs, initial investment costs, and annual operating costs. They are described as:

1. <u>Research and development costs</u> - represent all outlays necessary to bring a new system into readiness for introduction into operational use.

2. <u>Initial investment costs</u> - are those one-time outlays required to introduce new systems or new capability into use.

3. <u>Annual operating costs</u> - the recurring costs that must be incurred to operate and maintain the system after it has been initially introduced into the active inventory.

The three cost categories follow a chronological order, but generally some time overlap exists. Initial investment outlays have to be incurred before the research and development is completed and operations expenditures begin before the delivery of all units planned for the system.

Categorizing of system costs over the designated life cycle of the system is important for several reasons:

1. It is useful in identification of the total resource impact of a proposal.

2. Decision-makers may become so preoccupied with investment costs that the operating cost over a period of years as an inevitable consequence of their decision may get little attention.

3. The cost categories are useful for planning purposes. For example, a system with a higher initial investment costs but lower operating costs may, depending on the service life, become the least-cost system.

4. Trade-off possibilities between investment costs and operating costs can be examined through the use of cost categories.

5. Another use of cost categories is that they facilitate the analytical process. Research and development costs, for example, are one-time costs, and are essentially independent of the number of units that will be procured and the length of time the system will be in operational use. Expenditure for research and development creates possibilities for new products or new systems to solve a problem but usually does not itself provide new capability for an existing system.

Investment costs are a function of the number of units but are essentially independent of the system life cycle. Expenditures for investment may increase or add to the system capability.

Operating costs are a function of both the number of units and length of time that such units are employed. Expenditures for operation essentially support a system but do not add to it.

C. COST AND TIME

1. The Concept of Discounting

There should be some time value attached to money. It is a recognized fact that, in general, resources on hand today are worth more than identical resources available at a later date. It follows that money with which we can buy resources today is worth more than when it is available tomorrow.

The time value of money is often considered in analyses by discounting or computing the present value of future money. By converting future moneys to their present value, we can meaningfully add together dollars spent or received in different periods. The present value of costs, then, are the sum of all the discounted future costs computed for the projected time. It may be computed by use of the following equation:

$$PV = \frac{Cn}{(1+r_1)(1+r_2)----(1+r_i)----(1+r_n)} \qquad (1)$$

where:

PV = present value
Cn = future value in year n
r_1, r_2, r_i, r_n = the appropriate discount rate during the first, second, i th and n th year respectively.

For a constant interest rate equation (1) becomes

$$PV = \frac{Cn}{(1+r)^n} \qquad (2)$$

A system that is funded annually over a period of n years, the present value of its total costs are computed by the following equation:

$$PV = \sum_{i=1}^{n} \frac{Ci}{(1+r)^{n}} \qquad (3)$$

where Ci= sum of costs during i th year.

2. Inflation

Changes in the price level due to inflation or deflation may occur in future years. If a monetary unit, such as dollar, is used as a measure of cost, inflation or deflation will affect the costs of the various systems.

Since the purpose of a cost-effectiveness analysis is to compare the resource costs of competing systems, however, changes in price levels will not significantly affect the results if the time frame is the same. Since inflation or deflation will affect the costs of each system in essentially the same way, it is convenient to assume a stable price level or constant dollar in the estimation of costs of the alternative systems [12].

3. Sunk Costs and Incremental Costs

In cost analyzing, attempts should be made to identify and determine existing resources that may be used by a new proposed capability. There are usually some resources on hand

which can be utilized to some extent within the new system. These inherited resources are referred to as sunk costs.

Though sunk costs must be taken into account in cost analysis to determine the resource impact of the new system, these costs must not be included in the cost calculations. Sunk costs are the result of past decisions, and are, therefore, not relevant. Only the future cost or incremental cost related to the present is relevant to any new decision.

Incremental cost represents those increments of cost that will be incurred as the result of current decision of utilizing one or another of the alternatives available.

D. METHODS OF COST ESTIMATION

The costs implication of alternative proposals for future capabilities can only be predicted as estimates since future events are not known with certainty. There are three formal methods for conducting a cost estimation. They are the parametric cost estimating, the industrial engineering method, and the analogy method [23].

1. Parametric Cost Estimating

In parametric cost estimating, the total cost of a system is obtained from the relationship between ascribed physical or performance characteristics and highly aggregated compound costs. Thus, a functional relationship (model) which

related the various characteristics or parameters of the system to the total cost of the system must be set up before the cost estimation can be conducted. These functional relationships between cost and system characteristics are called cost-estimating relationships (CER). Cost-estimating relationship may take various forms, ranging from informal rules of thumb or simple analogies to formal mathematical functions derived from statistical analysis of empirical data [6].

2. Industrial Engineering Method

In using the engineering method, the system is broken down into its lower-level components and the cost of each component is estimated, usually by the use of crude parametric estimating method such as so many dollars/lb of material for direct labor or detailed breakdowns of the labor into standard operations with known times [2].

The cost of the system may be determined by summing the various costs of its components.

3. Analogy Method

Some early cost estimates must be conducted with little or no historical information on the system under consideration which permits parametric cost estimating. In such a case, when data are sparse, a specialized method of judgment may be used to estimate costs.

In this method cost estimates are accomplished by making direct comparisons with historical information on like or similar existing systems or their components.

This method of cost estimation, which is referred to as the analogy method, is the most widely used method of analysis, though it is surely not the most accurate [23].

E. COSTING THE ALTERNATIVES

1. Assumptions

Since there is no sufficient information available to conduct accurate cost estimates and also to limit the scope of the analysis, the following assumptions are made for the problem addressed in this thesis:

a. The patrol vessels are readily available on the international market. Their research and development costs are therefore not considered.

b. Research and development costs for the shore facilities are also not considered. The sites under consideration already have some of the required major facilities. Only some extention, addition, improvement or development of the existing facilities is needed.

c. The useful life of the patrol vessels as well as of the shore facilities is estimated as 20 years.

d. The buying power of the rupiah (the Indonesian currency) will remain constant and 1975 is considered as a base year. Thus, the effect of inflation or deflation is not taken into account.

e. A constant interest rate or cost of capital will be used in the determination of the present value of the total cost of each alternative.

f. No new repair facilities will be built at Surabaya to service the additional patrol vessels since the existing facilities are adequate.

2. The Cost Model

The cost model provides a method for determining the present value of expected net costs for the alternatives under consideration. In this section the estimating of costs that are relevant (to the choice of an alternative) will be discussed. To facilitate the determination of the expected net cost for each alternative, the system is broken down into two major components: the vessel and its supporting facilities. The cost of each major component is further divided into two cost categories, the investment cost and the annual operating cost. Each cost category is comprised of several cost elements as shown in Figure 2 on the next page.

The present value of annual cost for the n th year of each major component of an alternative is determined simply by

Figure 2

COST ELEMENTS OF THE PATROL VESSEL AND THE SUPPORTING ESTABLISHMENT

A. Cost Elements of a Patrol Vessel:

Investment Costs
1. Procurement and initial training

Annual Operating Costs
1. Pay and allowances
2. Fuel, oil, etc.
3. Repair and maintenance

B. Cost Elements of a Naval Station

Investment Costs
1. Housing and administrative facilities
2. Medical and dental facilities
3. Storage facilities
4. Berthing facilities
5. Communication facilities

Annual Operating Costs
1. Pay and allowances
2. Operation, maintenance and repair

C. Cost Elements of a Naval Base

Investment Costs
1. Housing and administrative facilities
2. Medical and dental facilities
3. Storage facilities
4. Berthing facilities
5. Maintenance and repair facilities
6. Ordnance facilities
7. Communication facilities

Annual Operating Costs
1. Pay and allowances
2. Operation, repair and maintenance

multiplying the estimated annual operating costs for that year by present value factor $\left(\frac{1}{1+r}\right)^n$, where r as before is the discount rate for the year n. The present value of the net cost of an alternative may then be calculated by the use of the following equation:

$$\text{P.V. of future costs} = Co + \sum_{i=1}^{n} Cn \left(\frac{1}{1+r}\right)^n \qquad (5)$$

where: Co = total initial investment costs
Cn = total estimated annual cost for year n.

3. The discount rate

One problem in dealing with future costs is the proper choice of a discount rate. The proper choice of a discount rate is crucial because an inappropriate choice may lead to a poor decision or to the selection of an inferior alternative. An alternative, when discounted at a 5% rate, for example, may seem to yield substantial benefits, but when it is discounted at a higher rate, it may appear inferior to the other alternatives if the time pattern of costs is quite different.

There are different interpretations about the appropriate discount rate to be applied in comparing nonmarketable projects such as defense [3]. Some people suggest that the discount rate should reflect the rate of interest on comparable types of investment in the market economy. Others feel it should be the interest rate that the government pays on its debts.

According to Fisher [6], the appropriate discount rate for use in comparing future dollars with today's dollars depends, just as cost depends, upon alternatives, the alternative opportunities available for investment. But the Navy has many alternative opportunities, each yielding a different return. Finding an appropriate discount rate might, therefore, be very difficult.

For the purpose of this analysis, the discount rate that will be used in discounting future costs is the rate of interest that Bank Indonesia (government bank) is willing to pay on long term deposits. This interest rate, as stated in the decree of the Board of Directors of Bank Indonesia on December 28, 1974, amounts to 24% [15].

Table 1 lists the present value factor over time at 24% discount rate. The present value factors are based on continuous compounding interest at constant rate.

4. <u>Cost of the Patrol Vessel</u>

a. Initial Investment Cost of a Patrol Vessel

Included in the initial investment cost are initial spares and repair parts and initial training for the crew. The estimated initial investment cost for a vessel is 500 millions rupiahs.* This figure is obtained from a personal interview.

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*Rupiah is the Indonesian currency. Its official conversion rate to the dollar when this paper is prepared is $1.00 = Rp 415.00.

TABLE 1

24% PRESENT VALUE TABLE

Year n	P.V. of Rp 1 $(1+r)^{-n}$	P.V. of Annuity of Rp 1 $\frac{1-(1+r)^{-n}}{r}$
1	0.8065	0.8065
2	0.6504	1.4568
3	0.5245	1.9813
4	0.4230	2.4043
5	0.3411	2.7454
6	0.2751	3.0205
7	0.2218	3.2423
8	0.1789	3.4212
9	0.1443	3.5655
10	0.1164	3.6819
11	0.0938	3.7757
12	0.0757	3.8514
13	0.0610	3.9124
14	0.0492	3.9616
15	0.0397	4.0013
16	0.0320	4.0333
17	0.0258	4.0591
18	0.0208	4.0799
19	0.0168	4.0967
20	0.0135	4.1103
21	0.0109	4.1212
22	0.0088	4.1300
23	0.0071	4.1371
24	0.0057	4.1428
25	0.0046	4.1474

Other data used in this thesis, if not otherwise specified, are obtained from personal interviews.

b. Annual Operating Costs of a Vessel

The annual operating costs of a vessel are those recurring outlays that are needed to operate and maintain the vessel after it has been introduced into service. The main elements of this cost category are: (1) Pay and allowances for the crew; (2) Fuels and lubricants; (3) Repair and maintenance.

(1) Pay and Allowances

Pay and allowances of a military personnel may include basic pay, subsistence allowance, family allowance, special allowances (this allowance is only for personnel whose basic pay is less than a certain minimum level), performance allowance (this allowance is given to military personnel of the rank petty officer and above), functional allowance (given only to commissioned officers), working allowance, clothing, retirement deduction, etc. The amount of pay and allowances of a military man depends upon his rank, his years of service, and his family size (he receives allowances for his wife and his first three children below 18 years of age). Since the real distribution of the crew of a vessel is not known, it is difficult to compute the cost of pay and allowances for the crew of a vessel.

The cost of pay and allowances can be estimated, however, by the use of the weighted average of cost of pay and allowances of a rank group. For example, if the weighted average of cost of pay and allowances for seamen is Rp 200,000, then, the employment of 10 seamen will require an expenditure of 10 x Rp 200,000 = Rp 2000,000 annually.

Table 2 lists the weighted average of the cost of pay and allowances of military and civilian personnel of various rank groups.

(2) Fuels and Lubricants

The annual cost of fuels and lubricants is estimated on the basis of the yearly operating hours of the vessel. The employment or maintenance policy as set forward is not to operate this patrol more than 1800 hours a year. As mentioned earlier, the fuel consumption of the vessel at its economic cruising speed is 100 gallons per hour and its lubricant consumption averages 7 pints an hour. The cost of fuel per gallon is Rp 72 and the cost of lubricants is Rp 120 per pint. These prices are of January 1975.

(3) Repair and Maintenance

This cost category represents the annual cost of materials used for the repair and maintenance of a vessel plus the cost of labor. This repair and maintenance cost for a vessel is estimated as a percentage of the initial investment

TABLE 2

THE ANNUAL COST OF PAY AND ALLOWANCES

Rank Group	Weighted Average of Pay and Allowances
Senior officer	Rp 900,000
Junior officer	Rp 670,000
Petty officer	Rp 450,000
Seaman	Rp 200,000

cost of the vessel. A 5% basis of the procurement cost of a vessel is used for estimating its repair and maintenance cost [4].

Figure 3 shows the present values of the total cost of a vessel as discounted over its 20 years service life at a discount rate of 24%.

5. Cost of the Supporting Establishment

a. Initial Investment Cost of a Naval Station or Naval Base

This cost category covers all those costs needed for installation, construction, or acquisition of additional facilities in order that the site under consideration can perform its function as a naval base or naval station as required. To determine the initial investment costs of these facilities, the existing facilities which can be used for the new system must be identified and the incremental construction requirements are then specified. The investment costs of the naval station/base are the cost of attaching the required new portion of the facilities to the existing facilities to bring them up to standard.

(1) Cost of Building and Construction

The usual method used for estimating the cost of building and construction is the application of a unit cost or cost per area of floorspace. To obtain an estimate of this cost, professional help is needed since there is no formal standard or guide reference available for the Indonesian Navy.

Figure 3

THE PRESENT VALUE OF THE 20 YEAR TOTAL COST OF A VESSEL
(in millions rupiahs)

Investment Costs			
- Procurement and initial training	=		500.0
Annual Operating Costs			
- Pay and allowances =		6.5	
- Fuel and lubricants =		14.5	
- Repair and maintenance =		25	
Total =		46.0	
Present value factor, for 20 years and 24% =		4.1103	
Present value of total annual operating costs	=		189.0
Present value of total cost of a vessel	=		689.0

The following are unit costs that have been obtained from personal interviews with cognizant people at the HQ of the Indonesian Navy:

Married officers quarters - Rp 8,500,000 per unit

Married petty officers quarters - Rp 4,000,000 per unit

Married seamen quarters - Rp 3,000,000 per unit

Officers mess - Rp 60,000 per square meter

Petty officers/seamen mess - Rp 50,000 per square meter

Clubhouse - Rp 25,000,000 per unit

Other buildings - Rp 50,000 per square meter

(2) <u>The costs of equipment</u>

These costs represent the costs of acquisition of additional equipment such as office furniture, medical equipment and machinery. The determination of the costs of the various equipment needed is a difficult task. The additional equipment must be identified and the amount specified before the cost can be estimated. Specialists in different fields must be consulted in order to identify what kinds of equipment are needed and how many of each is required. In addition, cost-estimating factors or data for each type of equipment must also be available to obtain total cost. Such information was not available to the author. Crude cost estimates of cognizant people will be used in estimating the costs.

b. Annual Operating Cost of a Naval Station or Naval Base

The annual operating costs of a naval station or a naval base are those recurring annual outlays which are needed to operate and maintain the facilities after they have been introduced into service. The annual operating costs of each facility generally consists of expenditures for personnel pay and allowances, materials and supplies, and repair and maintenance.

Methods used to compute annual operating costs depend upon the facility or activity under consideration. Annual operating costs for housing and administrative facilities, for example, could be computed as a percentage of initial investment costs or on the basis of size, type and function. Annual operating costs for medical and dental facilities may be estimated on the basis of cost per patient. Historical data and known costs of similar activities could also be used for estimating the annual operating costs of the other facilities. Historical data or other information that can be used for estimating the annual operating costs of each of the facilities were not all available to the author, so that the annual operating costs of a naval base or naval station could not be estimated by the method of summation of the annual operating costs of its facilities. Another approach for estimating the

annual operating costs of a naval base and a naval station must be used. One possible approach is to use cost information that is aggregated at a higher level. The annual operating costs may be divided into two major cost components, the personnel pay and allowances, and the costs for operation, maintenance and repair. Expenditures for pay and allowances are estimated by the same method as used for the computation of the personnel pay and allowances of a vessel's crew. Budgetary exhibits on an overall basis of other existing naval stations and naval bases of the similar size and activities may be employed in estimating costs of operation, maintenance and repair.

Figure 4 through Figure 9 exhibit the present value of total estimated costs for establishing a naval station or a naval base at the sites under consideration based on the several estimates mentioned earlier.

Figure 4

THE PRESENT VALUE OF TOTAL COST FOR
ESTABLISHING A NAVAL BASE AT S-1
(in millions rupiahs)

Investment Costs		
- Housing and administrative facilities	= 100.0	
- Medical and dental facilities	= 25.0	
- Storage facilities	= 25.0	
- Berthing facilities	= 100.0	
- Maintenance and repair facilities	= 450.0	
- Ordnance facilities	= 10.0	
- Communication facilities	= 830.0	
Total Investment Costs		= 1540.0
Annual Operating Costs		
- Pay and allowances	= 68.7	
- Operation, maintenance and repair	= 114.0	
Total Annual Operatinv Costs	= 182.7	
Present value factor for 20 years, 24%	= 4.1103	
Present value of total annual costs		= 751.0
Present value of total costs		= 2291.0

Figure 5

THE PRESENT VALUE OF TOTAL COST FOR ESTABLISHING S-1 AS A NAVAL STATION (in millions rupiahs)

Investment Costs				
- Housing and administrative facilities	=	--		
- Medical and dental facilities	=	20.0		
- Storage facilities	=	20.0		
- Berthing facilities	=	100.0		
- Communication facilities	=	--		
Total investment costs			=	140.0
Annual Operating Costs				
- Pay and allowances	=	56.5		
- Operation, maintenance and repair	=	27.0		
Total annual operating costs	=	83.5		
Present value factor for 20 years, 24%	=	4.1103		
Present value of total annual operating costs			=	343.2
Present value of total costs			=	483.2

Figure 6

THE PRESENT VALUE OF TOTAL COST FOR
ESTABLISHING A NAVAL BASE AT S-2
(in millions rupiahs)

Investment Costs		
- Housing and administrative facilities	= 150.0	
- Medical and dental facilities	= 85.0	
- Storage facilities	= 25.0	
- Berthing facilities	= 250.0	
- Maintenance and repair facilities	= 500.0	
- Ordnance facilities	= 10.0	
- Communication facilities	= 1000.0	
Total investment costs		= 2020.0
Annual Operating Costs		
- Pay and allowances	= 68.7	
- Operation, maintenance and repair	= 114.0	
Total annual costs	= 182.7	
Present value factor for 20 years, 24%	= 4.1103	
Present value of total annual costs		= 751.0
Present value of total costs		= 2771.0

Figure 7

THE PRESENT VALUE OF TOTAL COST FOR
ESTABLISHING A NAVAL STATION AT S-2
(in millions rupiahs)

Investment Costs		
- Housing and administrative facilities	= --	
- Medical and dental facilities	= 70.0	
- Storage facilities	= 20.0	
- Berthing facilities	= --	
- Communication facilities	= 49.0	
Total investment costs		= 139.0
Annual Operating Costs		
- Pay and allowances	= 56.5	
- Operation, maintenance and repair	= 27.0	
Total annual operating costs	= 83.5	
Present value factor for 20 years, 24%	= 4.1103	
Present value of total annual costs		= 343.2
Present value of total costs		482.2

Figure 8

THE PRESENT VALUE OF TOTAL COST FOR ESTABLISHING A NAVAL BASE AT S-3 (in millions rupiahs)

Investment Costs		
- Housing and administrative facilities	= 437.0	
- Medical and dental facilities	= 85.0	
- Storage facilities	= 65.0	
- Berthing facilities	= 500.0	
- Maintenance and repair facilities	= 500.0	
- Ordnance facilities	= 10.0	
- Communication facilities	= 1000.0	
Total investment costs		= 2597.0
Annual Operating Costs		
- Pay and allowances	= 68.7	
- Operation, maintenance and repair	= 114.0	
Total annual operating costs	= 182.7	
Present value factor for 20 years, 24%	= 4.1103	
Present value of total annual costs		= 751.0
Present value of total costs		= 3348.0

Figure 9

THE PRESENT VALUE OF TOTAL COST FOR
ESTABLISHING A NAVAL STATION AT S-3
(in millions rupiahs)

Investment Costs			
- Housing and administrative facilities	=	335.0	
- Medical and dental facilities	=	70.0	
- Storage facilities	=	50.0	
- Berthing facilities	=	500.0	
- Communication facilities	=	49.0	
Total investment costs			= 1004.0
Annual Operating Costs			
- Pay and allowances	=	56.5	
- Operation, maintenance and repair	=	27.0	
Total annual costs	=	83.5	
Present value factor for 20 years, 24%	=	4.1103	
Present value of total annual costs			= 343.2
Present value of total costs			= 1347.2

V. THE MEASURE OF EFFECTIVENESS

A. MEASURING EFFECTIVENESS

In order that the most desirable alternative may be selected, a method of representing a quantitative relationship between cost and effectiveness of each alternative under consideration must be made available. The measure of the cost for each alternative system is discussed previously. Though cost is difficult to measure, the choice of measures of effectiveness is often the most difficult part of cost-effectiveness analysis and there is no unique solution in many cases. Nevertheless, some measures of effectiveness must be chosen in order that the alternatives can be evaluated and the alternative whose capabilities meet the mission requirements in the most advantageous manner can be identified. Selection of a measure of effectiveness without fully understanding the problem structure and the mission may lead to measurement of a wrong performance parameter. This is unlikely to result in a good decision.

The appropriate measure of effectiveness should have two characteristics. It should be relevant with the goals or missions that the systems are to fulfill and it must be measurable or quantifiable [16]. These characteristics are often conflicting. The performance characteristics which are

most relevant are often very difficult to measure. On the other hand, the measurable characteristics often are not relevant.

It is preferable if the output or effectiveness of each alternative can be expressed in terms of one common medium, like dollars for cost. This will simplify the evaluation of the alternative proposals. Often, however, such a common denominator is difficult to define or is not available. In such cases, to make a rational choice among alternative systems, the benefit or effectiveness of each system is arranged according to some hierarchy of values [23].

The following are some quantifiable descriptors that may be used as guides in choosing an appropriate measure of effectiveness for the systems under study as suggested by the Air Force Economic Analysis Handbook [23]:

(1) Production - Number of items or commodities produced for each alternative, such as, hours flown, components manufactured, etc.

(2) Productivity - Number of items produced per manhour, volume output related to manhours.

(3) Operating efficiency - Denotes the rate of resources consumed by the system to achieve its output. For example, miles per gallon, BTU per hour.

(4) Reliability - This describes the system in terms of its probable failure rate. Useful performance measures may be mean-time-between-failure, the number of service calls per year, per cent refusals per warehouse requests.

(5) Accuracy - Measures performance errors per operating time period.

(6) Maintainability/Controllability - Has adequate human engineering been performed? Is the system compatible with adequately trained crew members? When the system does fail, is it difficult to repair because of poor accessability? A useful measure could be based on the average manhours necessary for repairs over a given time period, i.e., down time, or the crew rate necessary to control and maintain the system.

(7) Manageability - Considers how the workload of the organization will be affected by increased or decreased supervision or inspection time as a result of the proposed system.

(8) Integratability - Considers how the workload and product of the organization will be affected by the changes necessitated in modification of existing facilities or equipment, technical data requirements, initial personnel training, warehouse space for raw goods or parts storage, etc.

(9) Availability - May be described as the probability that a system will be ready for operation when called upon.

(10) Safety - Describes the number of accidents, or hazard involved.

(11) Durability - Considers the system's ability to perform at various environmental conditions, such as temperature range, pressure range, humidity, etc.

B. THE EFFECTIVENESS MODEL

The effectiveness model in cost effectiveness analysis provides a method for the estimation of a single quantitative measurement of performance characteristics for each of all alternative systems under consideration.

This section will attempt to choose an appropriate measure of effectiveness for the proposed alternatives. The method of measurement of this effectiveness will be described.

As mentioned earlier, the appropriate measure of effectiveness should have a meaningful relation to the objective and must be measurable.

The first task in developing an appropriate measure of effectiveness, therefore, is to understand the objective or mission established or assigned to the decision-maker.

The next step is to carefully examine the consistency and relevance of the measures of effectiveness available. The best combination of relevance and quantifiability is then sought.

The purpose of establishing a naval shore facility in the operating area, besides providing logistics support to the patrol vessels, is to eliminate time lost for steaming the distance from the operating area to home base, thus making more operating time available to the naval patrol vessels. Accordingly, availability of a patrol vessel in the operating area will serve as an appropriate measure of effectiveness. This measure of effectiveness can be expressed in terms of ship-hours available in the operating area during a year.

As stated in ref. 13 the employment and maintenance policy for the vessels under study is to operate them for 8 months during any year. The rest of the time is made available for maintenance and repair purposes. Each vessel is permitted to be employed not more than 1800 hours during one year of during that 8 months operating period. After every 1800 hours of employment each vessel must undergo a routine period of maintenance and repair. Ship-hours available during a year for each vessel can be computed by subtracting the hours lost for travelling to the home base and return from 1800. The hours lost for each vessel can be determined by dividing twice the distance from the home base to the site under consideration by the cruising speed (16 knots) of the vessel.

Table 3 depicts the time lost and available operating time of a patrol vessel for each alternative.

Table 3

TIME LOST AND AVAILABLE OPERATING TIME
FOR A VESSEL UNDER EACH ALTERNATIVE SYSTEM

Alternative	Location	Type of establishment	Distance to home base (naut. miles)	Time lost for travelling 2x distance (hrs)	Operating time available (hrs/ship/year)
1	S-1	Base	710	--	1800.00
2	S-1	Station	710	88.75	1711.25
3	S-2	Base	740	--	1800.00
4	S-2	Station	740	92.5	1707.50
5	S-3	Base	900	--	1800.00
6	S-3	Station	900	112.5	1687.5

Note: cruising speed = 16 knots

VI. EVALUATION OF THE ALTERNATIVES

The purpose of the comparison of alternatives is to identify which is the better system. In order to choose the preferred system, there must be some meaningful correlation between the cost and the effectiveness of each alternative system.

The total cost for each alternative system has been estimated in Chapter IV. The effectiveness of each alternative has also been measured in Chapter V. The estimated total cost of each alternative might be related to its effectiveness as depicted in Table 4 through Table 6 (pages 59 through 61). These relationships between cost and effectiveness of the six alternatives can also be illustrated in the form of graphs as shown in Figure 10 on page 62.

The most desirable system, however, cannot be selected just on the basis of the relationship between cost and effectiveness. Selection criteria are needed in order that the preferred alternative can be identified.

As mentioned earlier, the comparison of alternative systems is usually accomplished by the use of two selection criteria: Either a level of effectiveness which all systems must meet has to be specified and that system which meets this level at the lowest total cost is selected, or a level of cost (budget) is

Table 4

RELATIONSHIP OF MEASURE OF EFFECTIVENESS TO THE PRESENT VALUE OF TOTAL COST FOR ALTERNATIVE 1 AND ALTERNATIVE 2

	Alternative 1		Alternative 2	
No of Vessels	Operating time Available, ship-hours/year	P.V. of total cost, millions of rupiahs	Operating time Available, ship-hours/year	P.V. of total cost, millions of rupiahs
1	1800	2980	1711.25	1172
2	3600	3669	3422.50	1861
3	5400	4358	5133.75	2550
4	7200	5047	6845.00	3239
5	9000	5736	8556.25	3928
6	10800	6425	10267.50	4617
7	12600	7114	11978.75	5306
8	14400	7803	13690.00	5995
9	16200	8492	15401.25	6684
10	18000	9181	17112.50	7373

Table 5

RELATIONSHIP OF MEASURE OF EFFECTIVENESS TO THE PRESENT VALUE OF TOTAL COST FOR ALTERNATIVE 3 AND ALTERNATIVE 4

	Alternative 3		Alternative 4	
No of Vessels	Operating time Available, ship-hours/year	P.V. of total cost, millions of rupiahs	Operating time Available, ship-hours/year	P.V. of total cost, millions of rupiahs
1	1800	3460	1707.5	1171
2	3600	4149	3415.0	1860
3	5400	4838	5122.5	2549
4	7200	5527	6830.0	3238
5	9000	6216	8537.5	3927
6	10800	6905	10245.0	4616
7	12600	7594	11952.5	5305
8	14400	8283	13660.0	5994
9	16200	8972	15367.5	6683
10	18000	9661	17075.0	7372

Table 6

RELATIONSHIP OF MEASURE OF EFFECTIVENESS TO THE PRESENT VALUE OF TOTAL COST FOR ALTERNATIVE 5 AND ALTERNATIVE 6

No of Vessels	Alternative 5		Alternative 6	
	Operating time Available, ship-hours/year	P.V. of total cost, millions of rupiahs	Operating time Available, ship-hours/year	P.V. of total cost, millions of rupiahs
1	1800	4037	1687.5	2036
2	3600	4726	3375.0	2725
3	5400	5415	5062.5	3414
4	7200	6104	6750.0	4103
5	9000	6793	8437.5	4792
6	10800	7482	10125.0	5481
7	12600	8171	11812.5	6170
8	14400	8860	13500.0	6859
9	16200	9549	15187.5	7548
10	18000	10238	16875.0	8237

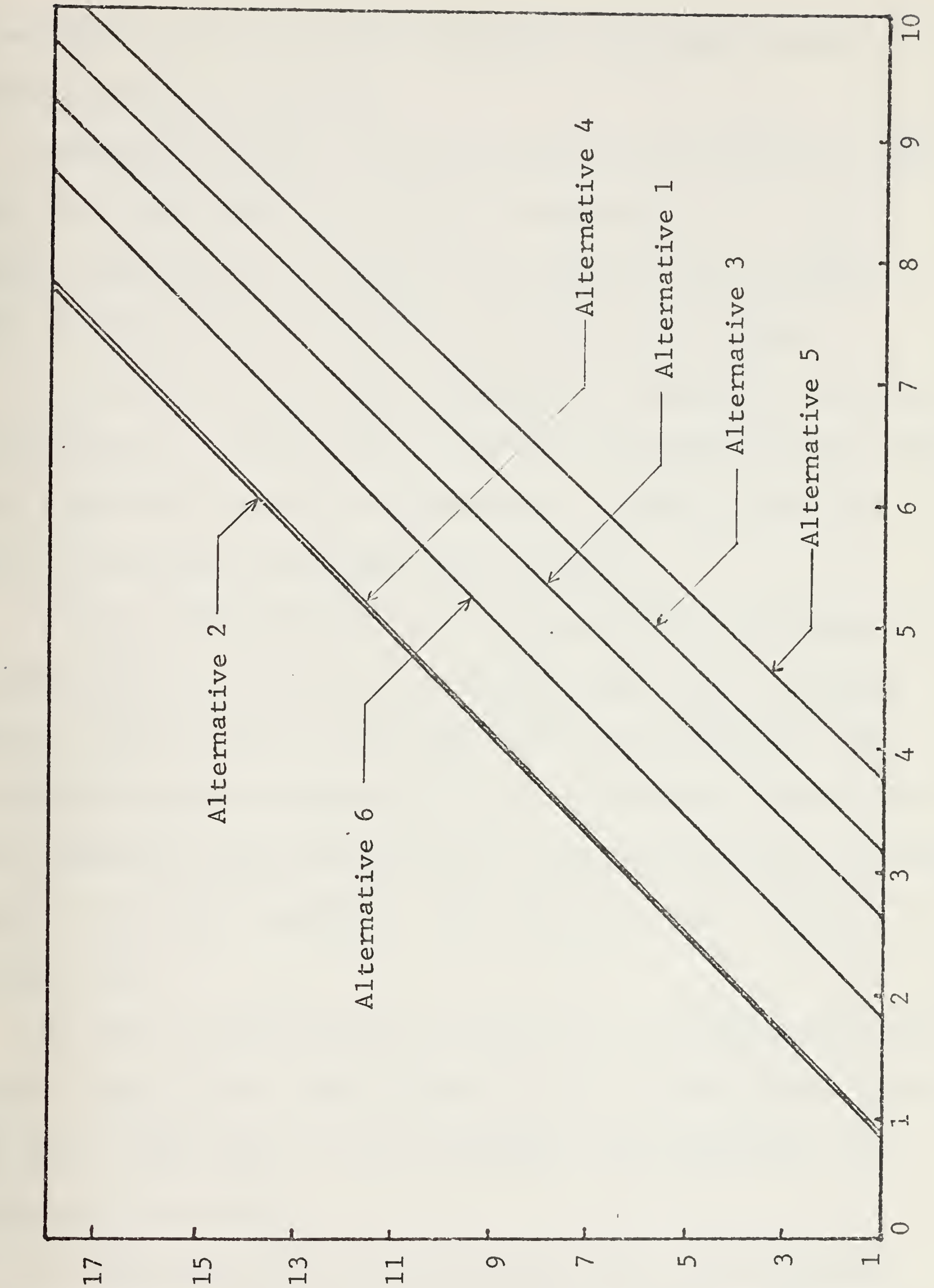
Alternative 4
Alternative 1
Alternative 3
Alternative 5
Alternative 2
Alternative 6
0
1
2
3
4
5
6
7
8
9
10
1
3
5
7
9
11
13
15
17
PRESENT VALUE OF TOTAL COST IN BILLIONS OF RUPIAHS
AVAILABLE OPERATING TIME IN THOUSANDS OF SHIP-HOURS/YEAR

Figure 10

specified and the system which provides the highest level of effectiveness is selected.

Referring to Figure 10 it is obvious that alternative 5 is the least cost-effective among the alternatives. For any given effectiveness it requires the highest expenditures, or for any given cost it provides the lowest effectiveness.

It can also be seen that alternative 2 dominates the other alternatives. For any level of effectiveness alternative 2 has the lowest cost among the alternatives, or for any level of cost it provides the highest effectiveness.

The cost-effectiveness line of alternative 2 in Figure 10 almost coincides with the cost-effectiveness line of alternative 4. This is due to the scale used in the drawing. The difference between alternative 2 and alternative 4 can be seen more clearly if the cost of each of these alternatives is plotted against its total ship-hours lost during one year, as shown in Figure 11.

In this case the selection criterion is to choose the alternative that has the lowest total time lost for any given level of cost. From Figure 11 it is obvious that alternative 2 is the preferred system.

It should be noted that this latter selection criterion cannot be applied to all six alternatives. This is due to the fact that alternative 1, 3 and 5 always have zero time lost at

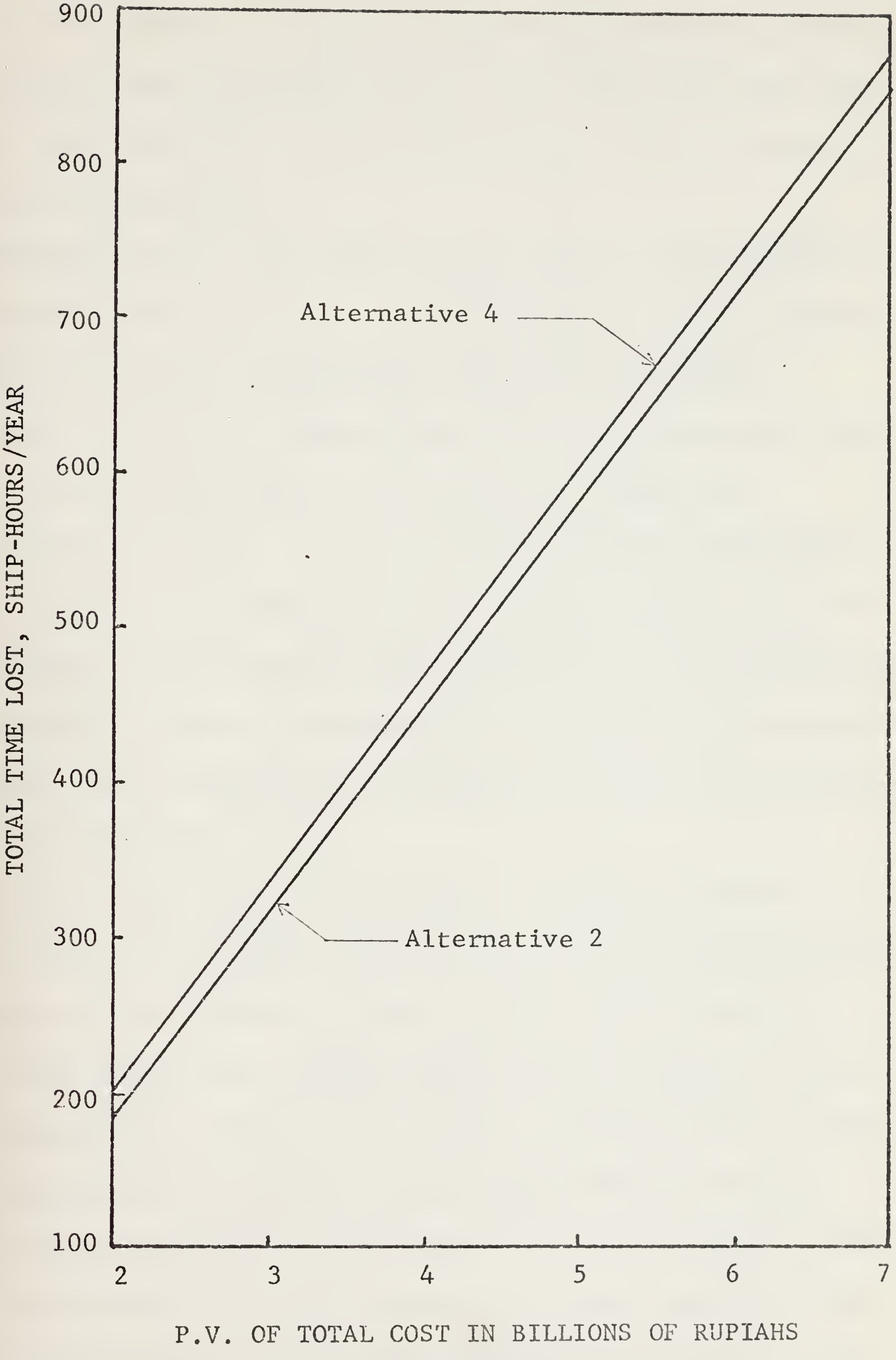
900
800
700
600
500
400
300
200
100
TOTAL TIME LOST, SHIP-HOURS/YEAR
Alternative 4
Alternative 2
2
3
4
5
6
7
P.V. OF TOTAL COST IN BILLIONS OF RUPIAHS

Figure 11

at any level of cost. If this criterion were used, the choice would fall either on alternative 1, 3 or 5 since they have the lowest ship-hours lost at any level of cost. Thus, it would lead to a wrong choice.

Extension of the cost-effectiveness line of each alternative in Figure 10 will result in cost-effectiveness lines as shown in Figure 12. The cost-effectiveness line for alternative 2 coincides with the cost-effectiveness line of alternative 4 due to the smaller scale used in the drawing of Figure 12.

As Figure 12 shows, the cost-effectiveness line for alternative 1 eventually intersects the cost-effectiveness line of alternative 2 at A, the cost-effectiveness line of alternative 3 intersects the line for alternative 4 at B, and the cost effectiveness line of alternative 5 intersects the cost-effectiveness line of alternative 6 at C.

Each of these intersections marks a break-even point. At these points, the present value of total costs for establishing a system to carry out the assigned mission are the same for a naval base system and a naval station system for equal levels of effectiveness. Point A, for example, indicates that a level of effectiveness of 90,000 ship-hours/year may be attained either by establishing a naval base at S-1 (alternative 1) with the acquisition of 50 patrol vessels (obtained from 90,000 ship-hours/year divided by 1800 hours/ship/year) at a present value

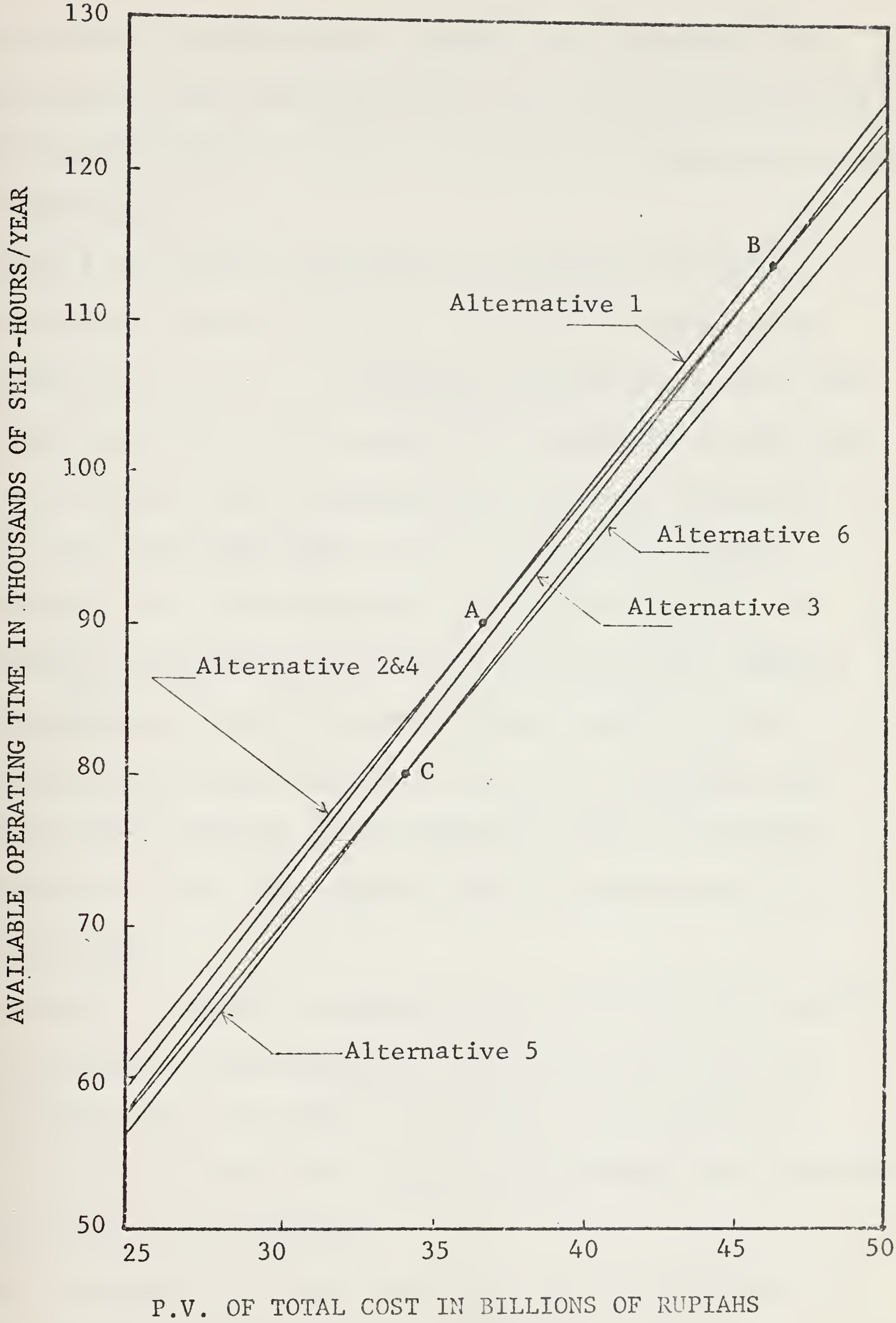
130
120
110
100
90
80
70
60
50
AVAILABLE OPERATING TIME IN THOUSANDS OF SHIP-HOURS/YEAR
25
30
35
40
45
50
P.V. OF TOTAL COST IN BILLIONS OF RUPIAHS
Alternative 1
Alternative 6
Alternative 3
Alternative 2&4
Alternative 5
A
B
C

Figure 12

of total cost of 36.8 billions rupiahs or by upgrading S-1 to a naval station with the acquisition of 53 patrol vessels (from 90,000 ship-hours/year divided by 1711.25 hours/ship/year) at the same total cost.

Point B and point C represent the break-even between a naval base and a naval station for S-2 and S-3 respectively. The break-even for S-2 is attained by establishing a naval base with the acquisition of 64 vessels or by upgrading of this site to a naval station and the acquisition of 67 patrol vessels. Point C, the break-even point of S-3, is reached either by alternative 5 with the investment on 45 patrol vessels or by alternative 6 with the acquisition of 48 naval patrol vessels.

The break-even points between a naval base and a naval station for these three sites are reached at such high levels of effectiveness because of the relatively high cost required to establish a naval base compared with the investment cost of a patrol vessel.

At point A, although alternative 1 and alternative 2 provide the same level of effectiveness at the same present value of total system cost, the choice is obviously on alternative 1. This is due to the fact that a naval base provides more additional benefits than a naval station.

The availability of repair facilities in a naval base, for example, besides rendering repair support to naval vessels

operating in its vicinity, it also lessens the repair burden of the home base. The larger number of activities of a naval base over a naval station will have greater social-economic impact on that region. For instance, more employment can be provided by a naval base than by a naval station. In addition, strategically a naval base has a greater worth than a naval station.

In the analyses it has been assumed that each vessel must return only once to the home base at Surabaya for its periodic maintenance if maintenance and repair facilities are not available in the operating area. There is a possibility, however, that between two periodic maintenance trips some equipment failures may occur. If such failures cannot be fixed at the naval station the patrol vessel must be sent to the home base. It is, therefore, interesting to know how many times a patrol vessel must return to the home base within one year, for a base system to be at a break-even point or more cost-effective than a station system. For this purpose an analysis on alternative 5 and alternative 6 will be conducted for a level of 6 vessels.

In order to determine this break-even point the total cost of the system over the total available operating time per year of the two alternatives had to be determined at several number of trips to the home base within a year.

The results obtained are listed in Table 7 and plotted in Figure 13.

As can be seen from Figure 13, the break-even point between a naval base and a naval station at S-3 is reached when <u>each</u> vessel makes 5 trips to the home base within one year. If each vessel must make 5 trips or more to the home base, the base system is more cost beneficial than the station system. Such a high number of trips within one year for each vessel, however, is not likely to occur. Further analysis to find the number of trips at break-even points for other alternatives is, therefore, not necessary.

On the other hand, if the result of the analysis shows a break-even at 2 trips, for example, further analysis to select the best alternative needs to be performed.

In conclusion, the cost-effectiveness analysis reveals that alternatives 2, 4 and 6 dominate alternatives 1, 3 and 5, or in other words, within the range of 10 vessels the establishment of a naval station is less expensive than the establishment of a naval base at any of the three sites under consideration, and that alternative 2 is the most cost-effective system.

Table 7

RELATIONSHIP OF TOTAL SYSTEM COST OVER THE TOTAL AVAILABLE OPERATING TIME PER YEAR AT A LEVEL OF 6 VESSELS TO THE AVERAGE NUMBER OF TRIPS TO THE HOME BASE OF A VESSEL FOR ALTERNATIVE 5 AND ALTERNATIVE 6

Number of Trips	Total cost/Total hour/Year Alternative 5	Total cost/Total hour/Year Alternative 6
0	692,778	--
1	--	541,333
2	--	580,000
3	--	624,615
4	--	676,667
5	--	738,181

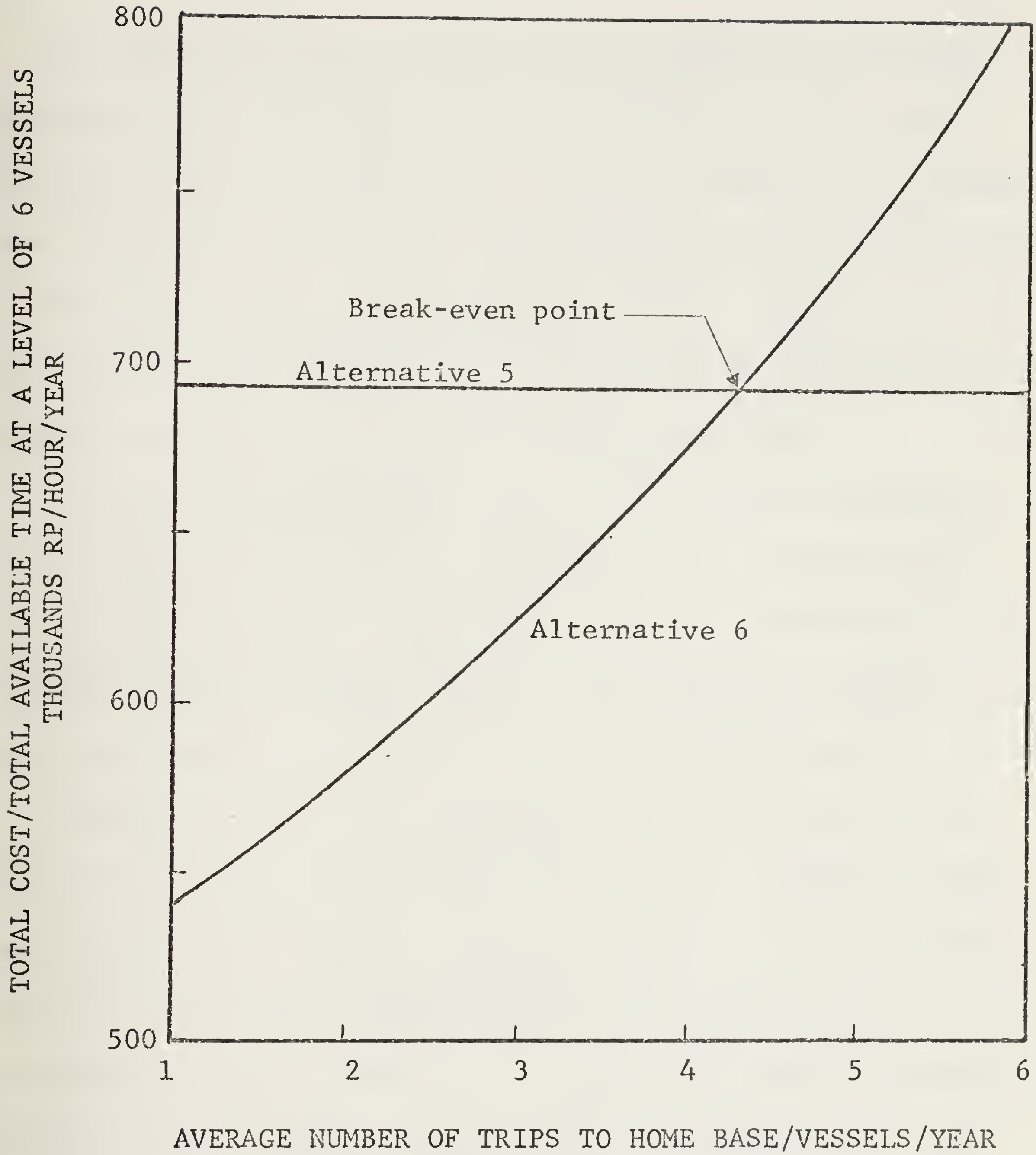
800
700
600
500
1
2
3
4
5
6
TOTAL COST/TOTAL AVAILABLE TIME AT A LEVEL OF 6 VESSELS
THOUSANDS RP/HOUR/YEAR
Break-even point
Alternative 5
Alternative 6
AVERAGE NUMBER OF TRIPS TO HOME BASE/VESSELS/YEAR

Figure 13

VII. CONCLUDING REMARKS

In conducting the cost analyses the author has received assistance and information from some officials at the Headquarters of the Indonesian Navy. Some information was obtained from personal interviews and some through personal correspondence.

The views and conclusions in this thesis, however, are of the author. They should not be interpreted as reflecting the official opinion or policy of the Indonesian Navy.

In estimating the future costs of the various components of each alternative system, some costs can be computed from the available data but some are based only on estimates of cognizant people because complete and accurate historical data are difficult to obtain or even are not available.

Essential to all cost estimation is the availability of complete and accurate historical data. With inadequate data, good quality cost analyses cannot be obtained. On the other hand, in long range planning great accuracy is not likely to be obtained, since systems will be subject to many unforeseen changes as they advance through the unknown future.

Although crude estimates have been used for costing the systems, the ranking of the alternatives should not be seriously affected. The systems are approximately similar and each cost

element is treated the same way. What will considerably affect the ranking of the alternatives is the information or estimate of the present condition of the existing facilities upon which the incremental costs are based. The validity of the results of the analysis, therefore, are still to be tested. As new information becomes available or as conditions change, new analysis may be necessary to obtain a better alternative, or one which was not considered in this analysis.

The analysis has led to the conclusion that the base system where the routine maintenance and repairs of the vessels are carried out at the home base in Surabaya is less expensive than the base system where repairs and maintenance of the patrol vessels are done in the operating area by establishing a naval base in this area. This is due to the fact that the ship-hours saved by establishing a naval base can be provided with less cost by procuring the patrol vessels.

Pay and allowances represent a significant portion of the annual operating cost of a naval shore establishment. Finding the appropriate level of personnel to operate a naval base or station is worth further study. The level of personnel required is determined by the organization. The organization, on the other hand, is not created to provide jobs to people but it is created to attain a certain mission.

Further development of this cost-effectiveness study for evaluating base systems would be very beneficial. Besides being used to identify the better base system it can also be an aid in making a decision of whether an existing shore establishment is to be developed or discontinued.

APPENDIX A

THE SUPPORTING FACILITIES

Certain facilities are necessary for a naval base and a naval station so that they can perform their function. Typical facilities required for a naval station are:

(1) Housing and administrative facilities

(2) Medical and dental facilities

(3) Storage facilities

(4) Berthing facilities

(5) Communication facilities

A naval base also comprises these facilities but usually they have greater capabilities than those of a naval station. In addition to these 5 major facilities, a naval base is equipped with maintenance and repair facilities and ordnance facilities.

For clarity, the terms used may be generally defined as follows [15]:

Housing Facilities. Housing facilities are accommodations assigned to military personnel with their dependents and civilians with their dependents. They are classified to indicate their designated use by category of occupants, such as married officers' quarters, bachelor officers' quarters, married petty officers' quarters, bachelor petty officers' quarters, married seamen quarters, or enlisted barracks.

Administrative Facility. An administrative facility is a building or portion of a building in which the affairs of a naval establishment or unit of naval establishment are administered.

Medical and Dental Facilities. A medical facility may consist of a hospital or dispensary or both. A hospital is a medical treatment facility primarily intended to provide in-patient care.

A dispensary is a medical treatment facility primarily intended to provide outpatient medical service for nonhospital type ambulatory patients.

A dental facility is any facility used for or in direct support of dental examination, treatment, prosthetic work, or other service.

Storage Facilities. Storage facilities are those facilities used for receiving, warehousing, and distributing naval supplies or designated types of naval material.

Berthing Facilities. Berthing facilities are structures designed for the berthing of vessels for repair, fueling, supply, fitting out, ammunition, and other essential services.

Communication Facilities. A communication facility consists of the buildings and accessories as well as the electronic equipment and integrated components which are installed to perform specific communication functions.

Maintenance and Repair Facilities. Maintenance and repair facilities include buildings, structures, and equipment designed for retaining naval material in a serviceable condition or restoring it to serviceability.

Ordnance Facilities. An ordnance facility is any structure or building in which explosives, propellants, ammunition, and small arms are stored and prepared for shipment.

The amount and categories of personnel necessary to operate the activities of a naval base or a naval station have been suggested as follows:

Personnel for a Naval Station:

- Senior officers	2
- Junior officers	13
- Petty officers and civilians of the same pay category	60
- Seamen and civilians of the same pay category	95
Total	170

Personnel for a Naval Base:

- Senior officers	3
- Junior officers	15
- Petty officers and civilians of the same pay category	70
- Seamen and civilians of the same pay category	122
Total	210

[21]

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